Mapping the Relief of Mount Ushba (Georgia) as a Contribution to an Alpine Club Map

by **Anouska Jaspersen**

Characterized by its double summit, Mount Ushba (Georgia) is one of the most prominent peaks of the Caucasus Mountains, close to the town Mestia. Tourism has been growing in the Mestia region over the past couple of years, with many hikers visiting the region. This led the Alpine Club to create a map sheet focusing on the hiking possibilities of the Caucasus region around Mount Ushba and Mestia, with a target scale of 1:33,000. This master thesis focuses on mapping the relief of Mount Ushba as a contribution to this Alpine Club Map. Using high-resolution PlanetScope imagery a digital elevation model (DEM) of the area is generated and evaluated and an exemplary relief depiction is created.

DEM generation

The digital elevation model is generated with PlanetScope imagery. The 136 small Dove-1 satellites image the entire Earth's surface every day in four spectral bands at a 3.6 meter resolution. 11 images of the Ushba region were selected and with stereophotogrammetry a 3D-model for the research area at the original resolution was created in Agisoft Metashape.

DEM evaluation

The generated DEM is evaluated by comparing the height values with existing DEMs, map sheets of the region and measurements taken in the field.

Shuttle Radar Topography Mission

The 1-arc SRTM data comes at a 30-meter resolution. The average vertical accuracy is 16 meters, although this can be up to 30 meters for steeper slopes (Ludwig and Schneider, 2006). Comparing the SRTM DEM and PlanetScope DEM does show a similar shape of the terrain (see fig. 1) but also height differences, with the largest deviations along the ridges and in sinks in the terrain. The RMSE of the height difference is 46.9m over the entire research area, but only 14m over more stable terrain.

Map sheets

The PlanetScope DEM was also compared to elevation points provided in map sheets of the region. This comparison shows that the PlanetScope DEM performs better than the SRTM DEM, with a RMSE of respectively 36.8m and 94.1m.

Field measurements

During the mapping campaign in the Ushba region in July 2021, the elevation was measured for 21 locations with GPS devices. Plotting and comparing the elevation differences with the PlanetScope and SRTM DEM, shows that the PlanetScope DEM performs slightly better (see fig. 2).

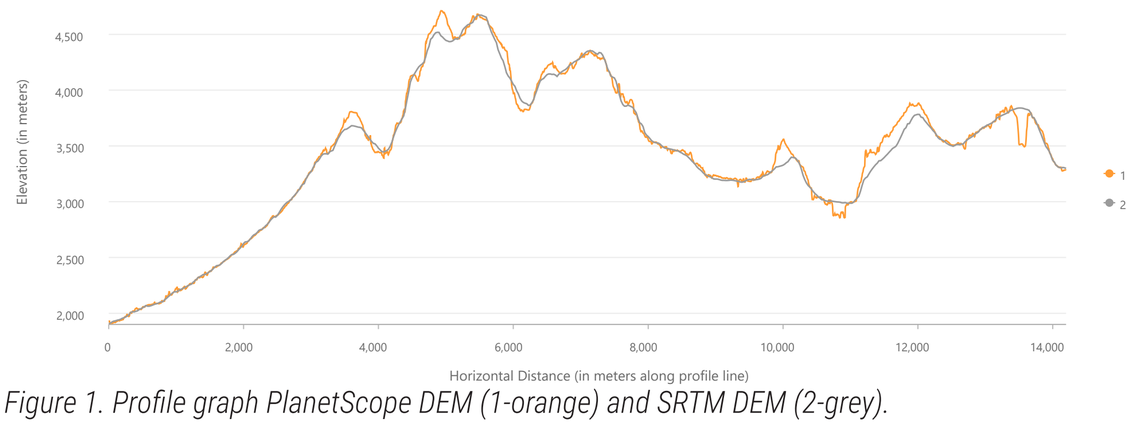
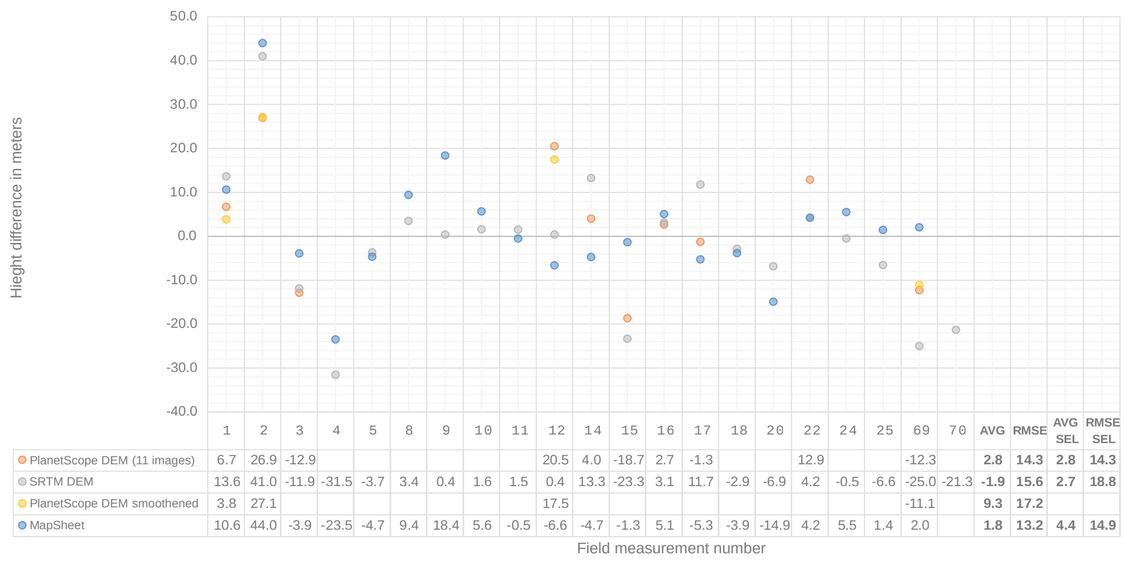


Figure 1. Profile graph PlanetScope DEM (1-orange) and SRTM DEM (2-grey).



	1	2	3	4	5	8	9	10	11	12	14	15	16	17	18	20	22	24	25	69	70	AVG	RMSE	AVG SEL	RMSE SEL
PlanetScope DEM (11 images)	6.7	26.9	-12.9							20.5	4.0	-18.7	2.7	-1.3			12.9			-12.3		**2.8**	**14.3**	**2.8**	**14.3**
SRTM DEM	13.6	41.0	-11.9	-31.5	-3.7	3.4	0.4	1.6	1.5	0.4	13.3	-23.3	3.1	11.7	-2.9	-6.9	4.2	-0.5	-6.6	-25.0	-21.3	**-1.9**	**15.6**	**2.7**	**18.8**
PlanetScope DEM smoothened	3.8	27.1								17.5										-11.1		**9.3**	**17.2**		
MapSheet	10.6	44.0	-3.9	-23.5	-4.7	9.4	18.4	5.6	-0.5	-6.6	-4.7	-1.3	5.1	-5.3	-3.9	-14.9	4.2	5.5	1.4	2.0		**1.8**	**13.2**	**4.4**	**14.9**

Figure 2. Elevation differences with field measurements (SEL calculations made only with the points present in PlanetScope DEM).

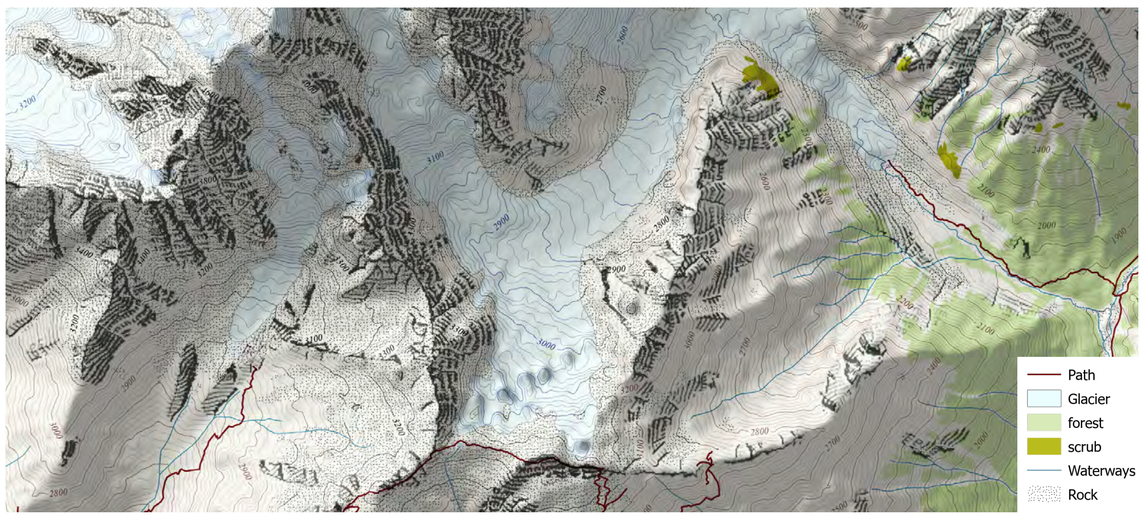


Figure 3. Section of exemplary relief depiction based on PlanetScope DEM.

Relief depiction

Based on the digital elevation model a relief depiction can be created. The DEM, however, still contains a lot of unnecessary detail that needs to be removed in order to create a legible depiction. This smoothing needs to be done carefully, so the ridges and valleys will not be smoothened out and the important landforms remain present in the terrain. By taking out the ridge and valley lines, and connecting these with a spline to the smoothened DEM, an accurate, but with less noise, DEM is created. Comparing the smoothened DEM to reference height data shows that it still performs well (RMSE of 39m with map sheets and even smaller devations with field measurements compared to original PlanetScope DEM).

Contour lines

With the smoothened DEM contour lines can be created. With an equidtistance of 20 meters and index lines every 100 meters, the isolines are legible and still accurately represent the heigt information in the map.

Shaded relief

The shaded relief of the terrain is created in Blender. This 3D-modelling program recreates the way light scatters, reflects and bounces on the mountains and how its absence creates shadows. It creates highly realistic shaded reliefs, improving the identification of important landforms.

Rock depiction

The depiction of rock areas is based on the dataset created by Schröder (2020) and the bedrock detected in existing map sheets. With Piotr, an automatic Swiss rock depiction program by Geisthövel (2017), the visualization is generated for the bedrock.

Conclusion

The results and evaluation show that is it possible to generate a digital elevation model of sufficient quality with PlanetScope imagery. The height deviations are rather large due to the mountainous terrain, but the PlanetScope DEM performs better in the accuracy assessments than the commonly used SRTM DEM. An exemplary map is created by combining OpenStreetMap data with the relief depiction and a section can be found in figure 3.

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Chair Professor: Prof. Dipl. Phys. Dr.-Ing. habil. Dirk Burghardt (TUD)
Supervisor: Dr.rer.nat. Nikolas Prechtel (TUD)
Reviewer: Dr.rer.nat. Georg Gartner (TUW)

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References

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